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ABSTRACT

Possible economic and social trends in world agriculture by year 2000 will include increased energy costs; larger, fewer and more specialized farms; decreasing agricultural population; closer ties between farmers and large agribusinesses; more emphasis on consumer and environmental protection; and an increased importance of agriculture in developing countries to economics and agriculture in developed countries. Farmers in developed countries may have changed attitudes toward farming and the land, and will rely more on computers, private consultants, technical aids and outside capital, so more control of agricultural production may be held by nonproducers. To avoid malnutrition and increased food imports resulting from population increase greater than increase in agricultural production, developing countries should invest more in: (1) agricultural research and education programs; (2) bringing uncultivated land into production; (3) increased yield and more intensive use of currently cultivated land; and (4) saving a greater percentage of crops produced. Diverting grain from livestock to human consumption, restrained population growth, higher status for women, and better pension and social security systems should also be considered. World-wide, agricultural production will increase; trade barriers should be relaxed to obtain a favorable trade balance; energy from biomass fuels may become important; and more efficient use of irrigation water will be necessary. (MH)

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By Earl O. Heady

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ECONOMIC AND SOCIAL CONDITIONS RELATING TO AGRICULTURE AND ITS STRUCTURE TO YEAR 2000

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ECONOMIC AND SOCIAL CONDITIONS RELATING TO AGRICULTURE AND ITS STRUCTURE TO YEAR 2000

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Agriculture is very dissimilar over the world. Its structure as expressed in farm size, labor and capital intensity and technology varies among regions and countries according to the stage of economic development. This heterogenous pattern resulting from uneven economic development will continue over the next 20 years and it is impossible to unfold a single scenario which will characterize all of world agriculture, or even of agriculture in developed countries. Time does not allow detailed discussion of the full range of potentials for the many groups such as mountain farmers with opportunities under growing tourism demand, subsistence farmers, part-time farmers in industrialized regions, the traditional European small family farm, the large-scale family farm and the industrialized farm under a range of climatic and soil conditions. Hence, I discuss only some major groups and tendencies. We can outline general tendencies for developed countries but still variations will occur by regions and countries. I will first discuss some of these trends in agricultural structure which will prevail as a result of economic growth within developed nations, regardless of food supply and demand conditions world wide. I then summarize some world food potentials and their implications for developed countries.

Some Developmental Effects

Under the long sweep of economic development, agricultural structure follows a "natural economic path". At low stages of development, the real price of capital is high and that of labor is low. Farming is labor intensive (labor is substituted for capital) and human labor serves as a source of energy and mechanical manipulation. Scale economies are small in labor agriculture and there is not pressure towards large-scale farms [10]. When labor is the major resource it can be used over a diverse set of enterprises. Farms are diversified accordingly, in producing both for subsistence consumption and for the market. As economic development progresses, nations accumulate capital and invest in the training and ability of people. The real price of capital declines accordingly while the relative price of labor increases as it embodies this larger human investment. Labor eventually becomes too costly to supply energy and mechanical manipulations in agriculture. Capital is substituted for labor accordingly. Since many forms of capital are discrete units, it has high fixed costs and gives rise to scale or cost economies over large areas or animal numbers. Accordingly, farms become capital intensive, and larger and fewer in number. Also as part of this "natural economic path", farms become more specialized at higher stages of development. Capital in the form of specialized field machines, feed handling equipment, etc., cannot readily be switched back and forth among swine, wheat, potatoes and poultry. Hence, with high fixed costs at high stages of development, farmers

specialize in one or two commodities to have a large volume, spread fixed costs and realize greater income. Hence, a different structure of agriculture is consistent with each stage of economic development.

I expect world economic growth to continue for the next 20 years even with higher energy prices. Accordingly, the general tendencies of all agricultures will be along that "natural economic path" of the continued substitution of capital for labor and land, fewer and larger farms and more specialization (except as restrained by institutional conditions). Because the starting point in economic development and farm structure differs so greatly among nations and within nations, how far farms progress along this "natural economic path" in two decades will vary greatly.

While farms in developed countries will continue to grow over the next 20 years, I do not see the large farm structure of Eastern Europe repeated in Western Europe, North America and other developed western countries. The structure and size of farms in Eastern Europe is not a function of scale economies. Under existing available technology world-wide, scale or cost economies are exhausted long before a farm reaches 4,000 - 8,000 hectares of 50,000 - 300,000 hogs.

At early stages of development in Europe and North America, labor and land were the major inputs of agriculture. Capital was a minor input and produced mainly on the farms where used. Consequently, the private sector did little research because of limited sales possibility for processed capital inputs. However, capital is now the major input

of agriculture in most developed countries. Much of it can be bagged, boxed and branded and marketed by private firms. Accordingly, the private sector will invest heavily in agricultural research and communication to increase demand for the capital inputs it processes. It will do so only for material inputs and not on such items as environmental quality, economic and social problems, and certain types of fundamental research.

Continued Postwar Tendencies

In its rapid recovery from World War II, agriculture in developed countries was surrounded by three ongoing but somewhat new phenomena: (a) A stage of economic development that lifted per capita income to levels causing food demand to become highly inelastic. Under inelastic demands, increases in food production faster than growth in domestic population and export demand causes the greater output to bring less, rather than more, market revenue to farmers. Surpluses for one or more commodities with this income depressing effect were common for most OECD countries at times of the last three decades. A complex of domestic and export subsidaries, which complicated market conditions of other countries, was generally the result of these surpluses. Food demand will grow even more inelastic in developed countries and population growth also will slow. Demand elasticity will remain relatively high only for such commodities as beef, convenience foods and selected others. (b) These market conditions brought forward a complex of trade barriers, internal

subsidies, external food aid and other conditions which thwarted trade and the comparative advantage of the results of agricultural research. Institutional and political considerations will determine whether these conditions will erode or intensify in the decades ahead. (c) The pressure towards structural adjustment of farms was great. The real price of capital in the form of machinery, power and biological inputs declined drastically relative to the price of labor. Capital was substituted for labor and land in farming with a consequent increase in size and reduction in number of farms. Small-scale operators were placed in a position of income depression due to the squeeze between farm commodity prices and input costs. Their level of living also trailed the upward surge occurring for families of larger farms, and the labor force and populace at large. A large migration of families from farm to urban employment or locations took place.

While the drawdown of labor in agriculture has been great, these trends to larger, fewer and more specialized farms will continue over the next two decades with a considerable further reduction in labor in numerous countries. As in the past, much of this labor may have little skill or experience for employment in other industries. A continued drawdown of the agricultural population will greatly handicap the functioning and provision of human services in country villages and rural communities, as it already has in many locations. Other economic and social forces molding the structure of agriculture and setting its social and economic environment over the past three decades have not yet been spent. They

will continue into the future until offset by emerging issues. The industry is going to continue its trend toward a high state of capitalization by commercial farms. This capitalization will continue to increase the proportion of fixed monetary costs. The continuing growth in the capital/labor ratio of agriculture will further specialization and subject farmers to increased risk hazards if national and international markets remain volatile. Risk preferences of farm entrepreneurs will be important in the capital and financial structures which become appropriate.

Other Structural Trends

Whereas the farm family formerly provided the capital or equity base upon which their businesses were financed, expanded and operated, this possibility is eroding as we move towards the millenium. The inflated values of land and capital equipment will increase the importance of outside capital intermediaries in financing agriculture and in controlling its investment and technology decisions. These forces, begun some two decades in the past, have promise of accentuation in the two decades ahead.

The high price of land and the great capital investment required for commercial agriculture will lead farms in several directions of ownership and tenure. The vast investment now required for commercial operation will allow only wealthy persons with access to large funds to both own and operate farms. The modest capital farmer of the past will be obsolete, except as a part-time farmer or as one hanging on until

retirement. The successful full-time operator will be one of high capability in ability to borrow and to conduct financial and farm management. Many will produce such large volumes and conduct such large businesses that they will increasingly employ private consultants for management and technology aids. They will have demands for advanced information systems and more of their decisions will be aided by computers.

In some European countries of modest sized family farms, the tendency may prevail for families to postpone retirement and hold the land to realize further capital gains from inflation. Others will be unable to compete through the market for it. With land held at great value in these patterns an extension of part-time farming will be encouraged. With modern machinery, however, what is now a "typical sized" commercial farm may turn out to be a typical part-time farm. The operator may be employed as a skilled worker or professional, but through the capability of modern machinery he also can operate what was once a medium-large farm in parts of Europe. His education and management capabilities will set him aside from previous generations of part-time farmers.

There is not yet evidence that market economies will eliminate inflation in the next decade. Land and commodity inflation in agriculture brings sacrifice to as many as it brings gains. Over the last six decades commodity inflation was capitalized rapidly into land prices. The result has been reoccurring price-cost squeezes on farm income. In countries where land markets prevail, inflationary gains generally do not carry

forward to subsequent generations who purchased land at inflated prices and experience commodity prices which are low relative to input prices. By the turn of the century, the majority of farmers will be those who bought land at high prices during or after the 1970's inflationary surge and many will face an ongoing cost-price squeeze under large interest and input expenses.

In countries of dispersed farmland, low density populations in typical rural areas, continued land inflation is likely to give rise to two groups interested differently in the technologies and income flows of agriculture and the value and use of agricultural resources. One group will have enough capital to own farm real estate and await a return which is reflected mainly in further inflation and capital gains. The other group may be that which operates and manages the farms. It would include persons who lack the capital for land purchase and put their more limited funds into operating capital. The owner group may be less concerned with technology and more with the rate at which land inflates in price. The manager group will realize its major economic gain from the ongoing operation of, and the continuous income flow from, the farm. Alternatives in farm technology will be of most importance to the manager group.

While a large share of Eastern Europe is organized as state and cooperative farms, group farming is practiced to an extent in Western Europe and there is intense discussion of corporate farming in North

America, prospects are that farms managed by farm families will still dominate in developed market economies by 2000. Family farms will simply grow much larger under most market conditions. Present technology and machinery can allow family farms to grow much larger in the future. A farmer with a 4-wheel drive tractor and complementary equipment can readily farm 800 hectares in the specialized grain regions of North America and Australia. With two such machine complements and a hired or another family worker, he can operate 1,600 hectares without management diseconomies. Family units of this size may be common in the North American future. For example, of 2.7 million U.S. farms, the 19 percent with the largest volume produce 78 percent of total commodity sales. Starting from a smaller size base, European family farms will grow proportionately if not restrained institutionally.

Values and Farm Structure and Policies

Historically, both farm and nonfarm families held unique values towards the farming occupation and the use of land. European Physiocrats considered farming to be one of the few occupations which in fact generated products of value. These notions of the virtues of farming as an occupation carried down to current decades. Farm families encouraged their children to enter the occupation and most of the labor force entrants were from farming. Complex inheritance systems, sometimes ineffectively, were fashioned to accomplish these purposes. The farm family quite typically looked upon itself as the steward of the land,

trusted to handle it carefully and to extend its productivity and use to future generations. The virtues attached to agriculture by the nonfarm population were quantified in the amount of subsidies and price supports supplied to farms in attempts to nullify effects of surplus supplies, undersized units and general income complexities. It is possible or likely, however, that these unique values held for farming and its resources are in the process of change. This possiblity arises partly because of the decline in the farm population as a portion of the national total. Farming now makes up less than 10 percent of the work force in some and as little as 4 percent in other developed countries. Many more developed countries will shrink to this proportion of the work force and population by 2000. In this setting there has been a tendency for both agriculturists and others to dismiss production agriculture as a unique occupation and to consider it as part of a larger system -- the food system, including processing and other phases. Whereas consumers or society at large previously could identify the large population strata representing farmers, it may be less able to do so with agriculture operated as large-scale units and looked upon simply as one link in the food machine. The inflation of prices generally, and of food processing in particular, may erase the tendency, held in the past, of the nonfarm population to sympathize with the farm population and actively subsidize family units so that they might continue to exist, The decline of the farm population to 2-4 percent of the total, the rush to large and few high-capital farms, and the identification of farming as simply part of the food chain may cause production agriculture to have little more sentimental

attachment by the national population than the petroleum energy, transportation, recreation or other sectors. Too, ongoing trends in the values of farm operators and families may accentuate over the next 20 years. The typical mood and attitude of farm families over previous decades in most developed countries was to highly value the farm operation per se. With partial equity obtained by inheritance or related means, the family worked industriously to maintain an acceptable standard of living, retire the farm's mortgage, live on its rental value in old age and pass it down through the family. Fewer young farmers now view farming in this light. Their income and management goals more nearly parallel those of a medium sized corporation or manufacturing firm president. The focus is now less on the farm as a physical entity and more on it as a business a generating cash flows and capital gains. The huge investments farmers in some countries have made recently to capture capital gains from rapid farmland price inflation add to this tendency. And it also could cause farmers to push for price policies which do not just support prices, but which push prices to higher levels consistent with continued inflationary capital gains in agriculture. In earlier times, farm families attached high value to soil conservation for attainment of the goals cited above. In recent years in the U.S., however, soil erosion has increased greatly as farmers specialized in intensive row cropping to capture the benefits of favorable international markets and to generate cash flows needed to finance inflated land prices. Interest has shifted partly from land to be conserved for the future, to consideration of it as a real estate

investment whose value increases with inflation even though continuous row-cropping erodes its productivity.

Consumer Interests, Restraints on Technology and The Environment

With its small population, agriculture will have little political power by 2000 in countries with two or three major parties. It may have more effect in countries with many small and fragmented parties where an agrarian concentration of votes can join other parties in forming a majority.

The values and views that society holds for agriculture and the decline in the proportion of the population engaged in farming poses the possibility of growing restraints over the technologies, or the employment of alternative technologies, employed by the sector. Because of their voting power, consumers readily can control the technologies employed in agriculture. They have already begun to restrain technologies which result in chemical and other residuals in food as a result of preservation methods, pest management systems and animal rations. Increasingly, they have become, and will continue to be, concerned with the interaction between agricultural technology and the environment generally. Bans on the use of particular pesticides and feed additives are now common. Locations and investments for large-scale specialized livestock units have been restrained similarly because of their contribution to atmospheric and stream pollution. Similar public concern over nonpoint pollution is

certain to bring legislation to limit soil erosion and restrain cropping practice, tillage methods and land use systems accordingly. Some agriculturists fear that the control of decisions and functioning of farming will pass to the broader agribusiness or food system mentioned previously.

Other Societal Relationships

The tendency for the agricultural population to average older in age will prevail as farms continue to become fewer and large or as older farmers hold onto their land to realize further inflationary gains. In the remoter rural areas, lack of off-farm employment opportunities for housewives will continue to draw younger families toward urban regions. Also, the opportunities for and roles of women in agriculture will need to change. With the smaller families projected for the future in developed countries, the mechanization of household duties and a greater extent of food preparation purchased with foods, the farm housewife will have more time for other pursuits. A challenge of the future is to provide her with background, training and opportunities within a rural setting or in farming which are as attractive as the challenges available in urban regions.

With declining birth rates, the agricultural work force may not be able to replace itself in its traditional manner. More persons from other sectors may have to be drawn into it if enough farm youth also are attracted to other occupations. With more effective education and job

communication, farm youth will continue to be drawn to the large megalopolis regions which spawn employment opportunities, especially in the growing employment area of human services. The megalopolis is nearly certain to continue to grow because people move where the employment is. And while inner cities decline in population, the megalopolis or urban region will continue to decentralize and spread over more area [8]. As it does, it will absorb more of the productive land which typically surrounds large cities. Higher family incomes in the developed countries also will generate pressure for use of more land for recreation, transportation and related uses. In countries or regions where distances are not great, further growth in per capita income will cause more people to search out second homes in the country for weekend use. To the extent that they have agricultural interests, it may be more in horticulture, floriculture, animal pets and similar phenomena.

Growth of labor productivity in the OECD developed countries has slowed considerably since 1973. This is true for agriculture as well as the general economy of these countries. There are numerous reasons for this overall slowdown including the implementation of policies to check inflation and reduced relative expenditures on research and development. It appears that it may take a decade to reverse this trend, but it may be prolonged if inflation is not checked, appropriate investments are not made in research and development and much higher energy prices prevail.

Concentration and Controls

Agriculture has been and will continue to be surrounded by conditions leading to concentration and integration. Concentration occurs, of course, as farmland is incorporated into fewer and larger farms. But economic concentration also is occurring in the agribusiness sector supplying farm inputs and purchasing and processing farm outputs. Under the extremes of these conditions, some farming has become fully vertically integrated with agribusiness firms in several developed market economie countries. Unless legislation is otherwise, the vertical integration of agriculture promises to be even more widespread in the future as farm size increases in more countries and the growing capital requirements of farming encourages this linkage with other agribusiness firms. In a few cases (e.g. broilers and seeds) some agricultural production now more nearly qualifies as an industrial enterprise than as a traditional farm enterprise. More of agriculture which is not land based, or which is intensive and uses a small land area, will pass into this industrialized realm in the future. These economic linkages will further the transfer of certain controls and decisions of farming out of the agricultural sector. Somewhat related to this complex is the growing use of forward contracting, hedging, production by specification and other non-traditional marketing methods.

Other types of economic concentration also are growing. Whereas farmers once produced most of their own inputs, today's commercialized farming

purchases the vast majority of its inputs from industrial sources. Farming will increasingly depend on purchased inputs. But the tendency in developed market countries is for firms supplying these inputs to merge into larger and fewer firms. The number of firms producing and distributing inputs such as farm machinery, chemicals and seeds has declined greatly and will continue to do so in the absence of restraining legislation. Of course vertical integration and other developments also is causing continued concentration of firms in farm commodity markets. With momentum towards a small number of large commodity firms and government organizations to conduct the world grain trade already building up, little is yet known of the price effects for farmers and consumers.

Potentials in World Food Supplies and Markets

Trends in the supplies of, and demands for, food in developing countries will have extreme importance on economic conditions surrounding agriculture of the world and the developed countries. Lagging agricultural development relative to population growth could cause the extent of malnutrition, and perhaps food imports by developing countries, to increase. Assessments of world food producing potentials have not been entirely consistent. The Club of Rome [13] is pessimistic under any scenario. The IFPRI [12] estimates that developing market economy countries will have a 10 percent gap between production and "needed food consumption" by 1990. Presumably, the situation would be worse by 2000. (These are projections of what may happen in the developing market countries, and not of what

will happen. The deficits could, for example, be offset by imports from surplus-producing developed countries.) Other studies project more optimistic potentials. Buringh, et al [3] estimate that the absolute maximum potential food production is 40 times greater than current production. Clark's [5] estimate of potential production is even larger. Considering some more moderate projections, our own estimates [1] indicate that with trend level of technology, some additional land brought under cultivation and irrigation and medium levels of population growth, the world food supply-demand balance could improve world wide up to 2000. Estimates by Rojko, et al [17] and Ray, et al [16] suggest a similar potential. The National Research Council indicates that food producing in the developing countries could double by 2000 while in the high income countries grain production could be increased by an amount greater than U.S. current production. They state that these levels could be attained at reasonable costs even under the rising costs of energy, water and other inputs [10]. Under these potentials, if agricultural development can be speeded up, food production has the potential of increasing by 3.5 percent per year in developing countries.

Optimistically, then, there is potential for world food production to increase somewhat faster than population up to 2000. Existence of the potential does not guarantee implementation of policies to attain it, however. And there is a shortage of trained manpower in developing countries for positions of research, education, administration and policy

management. One estimate [15] indicates that developing countries still need 30,000 new university graduates per year over the next 20 years for a sufficient agricultural research and education program and to promote agricultural development at a reasonable rate. Over the past three decades, management and trained intellect undoubtedly have been a greater restraint than lack of capital in getting greater development accomplished. However, while trained manpower will still serve as a restraint over the next 20 years, the developing countries now have a vastly greater pool of trained manpower than 30 years ago. I believe that there is enough managerial ability and unexploited production capacity so that food supplies particularly with some slackening in birth rates, can grow faster than population over the next 30 years. There are numerous potential sources of food which need exploiting: (a) By increasing yields on cultivated lands through improved varieties, fertilization, pesticide control, water management, research and technology transfer: The opportunity is considerable. Developing countries have 60 percent of the world's cereal area and produce 36 percent of the grain while the developed countries produce 64 percent on 40 percent of the area. While both developed and developing countries produced around 1.15 tons of grain per hectare in the period 1934-38, the developed countries had lifted yields to 3.0 tons by 1973-76 while the developing countries had attained only 1.4 tons (the U.S., 3.5 tons for all grains and 5.0 tons for corn while some countries have attained 6 tons for rice). (b) By more intensive use of

currently cultivated land, through multiple cropping, intercropping, and related means that more efficiently use available rainfall and solar energy and improve water management, laws and pricing. Less developed countries generally have climates with long or year-around growing seasons, conforming with multiple cropping possibilities and flexibility in cropping seasons. (c) By bringing uncultivated land into production: FAO [2] suggests that around 125 million hectares might be improved and irrigated over a decade. Evidently sizable areas not under crops or devoted to shifting cultivation could be cropped. It has been estimated [4, 6, 18] that of potentially arable land, only 22 percent in Africa, 11 percent in South America, and about 45 percent worldwide is now under cultivation. Buringh, et al [3] estimate that cultivated area might be increased by 140 percent and that irrigated land could be more than doubled. Clark [5] puts the world's potentially arable land at 9,000 million hectares, several times the amount now in use. These figures are undoubtedly far too optimistic, and use of some fragile lands would cause environmental deterioration. However, land is not a scarce resource in all parts of the world or there would be less shifting cultivation. These figures suggest some feasible expansion in the arable land base over the next two decades, but greatest potential for increased food is in improved technology and intensification of production on lands already cropped. FAO [7] estimates that increased food production by developing countries potentially can come 28 percent from expansion of cultivated area and 72 percent from more intensive cropping. (d) By saving a greater proportion

of crops that are produced: Estimates indicate high losses in developing countries, to rodents, birds and spoilage. FAO estimates these losses to be 10 percent of production in 1985 [7]. (e) By diverting grains from livestock to human consumption: This controversial alternative implies shifting a greater proportion of the world's grain consumption from rich countries where per capita consumption of meat is high, to poor countries where direct grain consumption is high and grain consumed through livestock is low and policies to implement it are unlikely [10].

These potential sources of food production should allow the average diet of the world to improve somewhat over the next 20 years [1]. However, the malnutrition of nearly a half billion people in poor countries will not be alleviated as long as their incomes are at poverty levels. Even, then, world food demand should grow more rapidly than population with further gains in per capita income and improved income distribution in developing countries. Demand for grain to be used in meat production, and for some other commodities with high income elasticities of demand, will grow rapidly in middle income countries. Because of the relatively lower costs, poultry will make up a greater proportion of meat production to meet this increased demand. Competition between developed countries for land devoted to forage for beef production and low income countries for land devoted to grains for human consumption will increase as per capita incomes in both sets of countries increase.

Developing countries will need to greatly increase use of inputs if world potential food production is attained by 2000. FAO estimates that to increase food production per annum by 3.8 percent to 2000, developing countries will need to double labor use, and increase fertilizer use by 5.0 times and improved seeds and pesticides by 2.5 times. Tractor use would quadruple [7]. Competition between developed and developing countries for these inputs and the energy to produce them will keep their prices high.

There is not yet solid evidence that yields are plateauing in developed countries and certainly no need for them to do so in developing countries. With food demand and international grain trade increasing somewhat faster than world population, commodity prices should be at somewhat higher real levels than during the 1950's and 1960's and thus be able to support a portion of the inflated land prices in developed countries. However, although grain prices may be relatively "good" as compared to recent decades, food supplies are likely to be sufficiently abundant to prohibit "run away" prices over the next two decades. In the absence of effective world buffer stocks, a somewhat more profitable agriculture over the next 20 years will still be faced with market instability; with prices tending to be relatively depressed during periods of normal world weather but bouncing to relatively high levels in periods of crop shortfalls in major world regions. Variability of supply and prices also is likely to increase as the world more fully uses its food production

resources. These fluctuations and risk aversion of farmers may dampen investments in land conversion and improvement in developing countries. Even with somewhat more favorable real prices for agricultural commodities, farmers in developed countries who have borrowed vast amounts of capital to buy land at prices which cannot be supported by ongoing price levels will remain in a financial squeeze and continue to press for high price guarantees.

Western Europe made a very rapid comeback after World War II because it had a large pool of management capabilities and was able to utilize efficiently the capital aid made available. Perhaps the developing countries could approach these possibilities in the future if they place enough value on agriculture. In the past their general tendency has been to undervalue agriculture -- in the relative paucity of funds for research, in keeping agricultural commodity prices too low (i.e., below world price) by means of export taxes, compulsory deliveries and price policies directed at benefit of the urban masses, and in small allocations of capital investments to agriculture, etc. It is estimated that 46 of 50 developing countries surveyed has pricing policies which serve as a disincentive in agriculture [7]. Long before 2000 developing countries will need to have enacted favorable pricing policies if the large investment to attain potential food production levels are reached.

In recent times, the developing countries have been investing only about a third as much in research, relative to value of product, as

have the developed countries. We cannot expect the international centers to fill these voids in the sense of generating results which are adapted to all of the local conditions over a large number of countries. I am hopeful, however, that political conditions will remain relatively stable, that the need for investing in, and placing a higher value on, agriculture will become better understood and the management, administrative experience and expertise will prevail to accomplish needed research and development. Certainly the next 25 years in developing countries will be more productive than the past 25 years.

Under a combination of some reduction in birth rates, modest growth in per capita income and stepped-up agricultural development, import requirements by developing countries could still increase considerably by 2000. However, in order to have a favorable trade balance and be able to purchase grain from each other and developed exporting countries, trade barriers would need to be relaxed throughout the world. This would be true not only for food commodities, in order that food production could be increased through comparative advantage production patterns among countries, but also for other commodities so that developing countries which import food can have more favorable trade balances.

I have been speaking of the period up to 2000, the task assigned for this paper. Longer-run problems and potentials in the world food supply-demand balance are quite different things and rest dominantly on what developing countries do with respect to birth rates. In the very long

run, the solution can never be provided through food supplies but must be attained through restrained population growth. These population restraints will be attained only by complex economic and social processes. Most important, the status of women must be increased in a manner which increases their economic and social opportunities. Their opportunities must be extended beyond farm and household work and the production of children. Data from developing countries shows that elasticity of births is -.25 for the education of woman and -.33 for income of women. In contrast, the elasticity of births is +.33 for income of men [9]. In addition to these needs for women, appropriate pension and social security systems must be developed so that families do not give birth to large numbers of children in order that they will be certain of some to support them in old age.

Increasingly, analysts and politicians have become more concerned with equity in income and employment opportunities as development of agriculture progresses. This tendency will increase, especially if developing countries prove more successful in increasing food output. While little research has application just to small farms and landless laborers, pressure will grow to turn efforts in this direction. Too, even in developed countries, equity within agriculture may become a more focused goal of policies. Agricultural policies of the past have been concerned mainly with equity between agriculture and the rest of society, and not within agriculture.

Other World Developments

Other world developments will affect the agricultures of developed countries. One is the certainty of much higher energy prices, perhaps 2.5-5.0 times present prices by the 1990's. Production agriculture uses only a small proportion of total energy in developed countries and is likely to have priorities for food production. However, energy intensive agricultural sectors will suffer from high energy prices. Energy costs are becoming an important component of farm operating costs. Impacted especially may be the spatial distribution of agriculture, the extent of irrigated agriculture from groundwater sources and perhaps the methods and forms of food processing. Potentially, too, a portion of agricultural could, encouraged by prices, be turned to energy production by 2000. The conversion of crop residues into biomass fuels is a distinct likelihood and the economic derivation of alcohol from conventional crops has positive probabilities. Even the production of energy crops per se on land less adapted to food production is a possibility which will press for investigation in 20 years. Land use competition will be severe if rich countries bid for use of some world land for production of energy while poor countries bid for use of this same land as a source of food.

With the LDC's producing only 40 percent of the world's grain supply on 64 percent of the world's grain area, yields in these countries need not plateau in two decades, unless energy prices rise to such high levels that use of pesticides and nitrogen fertilizer is highly curtailed.

Biological nitrogen fixation will need to become a more important process of agriculture as fossil supplies and prices rise as fossil fuel supplies dwindle and prices rise to 2000. Yields of specific crops in some developed countries increased only slightly in recent year. High energy prices could accentuate this tendency. The agricultural technology which emerged in recent decades and allowed a decline in the real price of food (at least the farm-gate component) was based largely on low real prices for fossil energy and for fertilizer, pesticides and other imports derived from it. With rising real prices for fossil energy, and the potential that substitute sources will have rising real prices, the major agricultural inputs with biological effects also will have rising real prices over the next two decades, thus deterring their previous role as substitutes for both land and labor in agriculture. This contrasts to the period following World War II when yield-increasing technologies gave a mammoth surge in agricultural productivity in developed countries. While farms will increase in size and decrease in number, still reducing the work force needed in agriculture as larger machines are used, the decline in farm population will be slowed relative to the period of low real prices for capital inputs over the period 1950-73. While the lowest cost sources of irrigation water already have been exploited in developed and developing countries, water may serve somewhat as a substitute, in a national sense of food production, for petroleum derived

inputs. Water from surface sources, if used by means of conserving technologies, especially may develop into a further substitute for land and other biological inputs. Hopefully, in a period of 20 years some of the institutional, legal, historic and other customs and barriers which cause irrigation water to be used and allocated inefficiently can be eliminated.

I have discussed some of the more apparent and likely economic and social conditions which can and will surround agriculture over the next 20 years. Obviously, unpredictable and mammoth institutional changes could take place in major countries and world regions and give rise to other conditions. For example, one scenario could include decisions by the U.S.S.R. and other Eastern European countries to further upgrade consumer diets and import more grain. If China moved similarly, total international grain trade would explode further and food could take on a much higher real price.

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